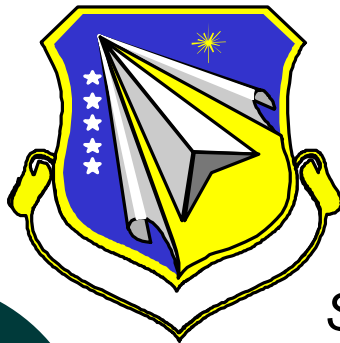
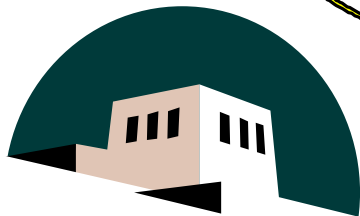


# Compositional Abruptness at the InAs-on-GaSb Interface:

## Optimizing Growth by Using the Sb Desorption Signature



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# Definition of Problem

- ▶ Excessive anion intermixing at the InAs-on-(In,Ga)Sb interface is usually observed.
- ▶ Anion intermixing is not well-controlled, and its origins are not well-understood.
- ▶ Inability to control anion intermixing results in poor reproducibility of type-II transition energies and recombination efficiency, as well as inconsistent match with theory.

# In this work, we ...

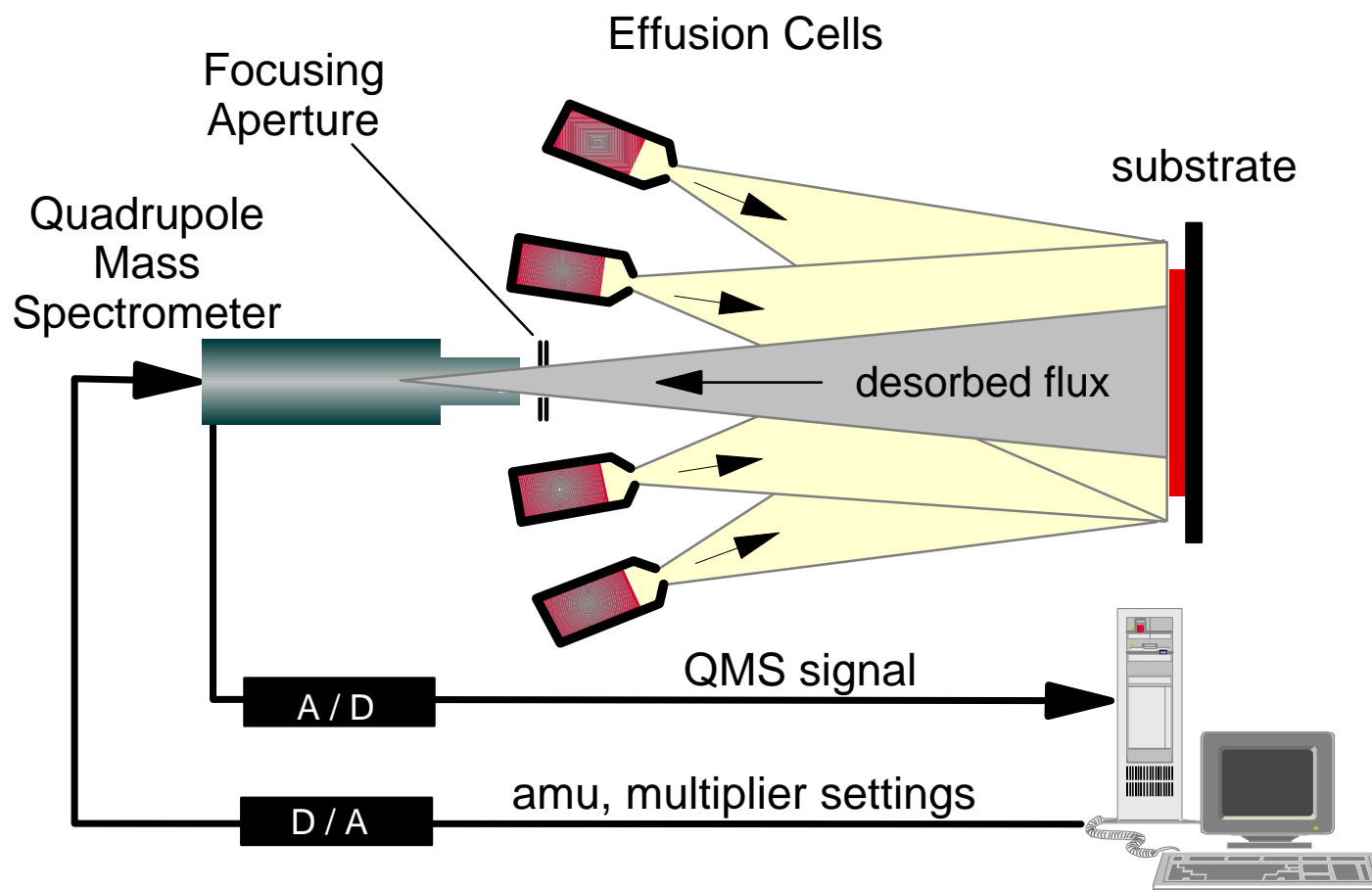


- ▶ ... use in-situ desorption mass spectrometry (DMS) to study the origins and kinetics of anion intermixing,
- ▶ ... directly observe 1) As-for-Sb exchange in GaSb, and 2) Sb-surface riding and incorporation in InAs,

## ... and conclude that ...

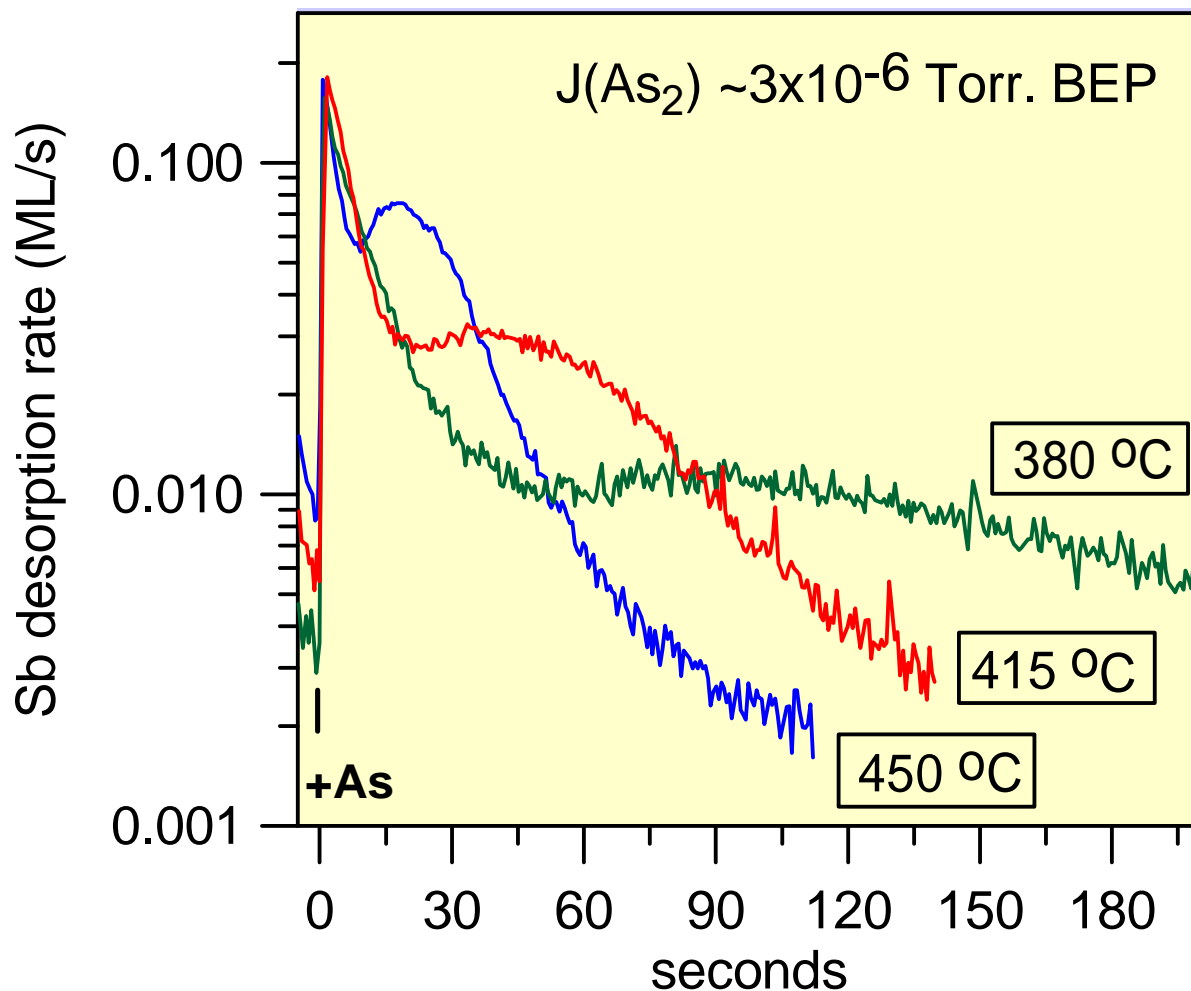
- ▶ ... there is always a large population of excess Sb at the GaSb surface that can mix into the InAs layer,
- ▶ ... to achieve a compositionally abrupt interface, one must remove the excess Sb without damaging the GaSb layer. A precisely controlled As-soak step may be the key.
- ▶ ... Sb desorption signature allows the optimization of MBE parameters to improve compositional abruptness.

# Desorption Mass Spectrometry in MBE





## GaSb is unstable when exposed to $\text{As}_2$



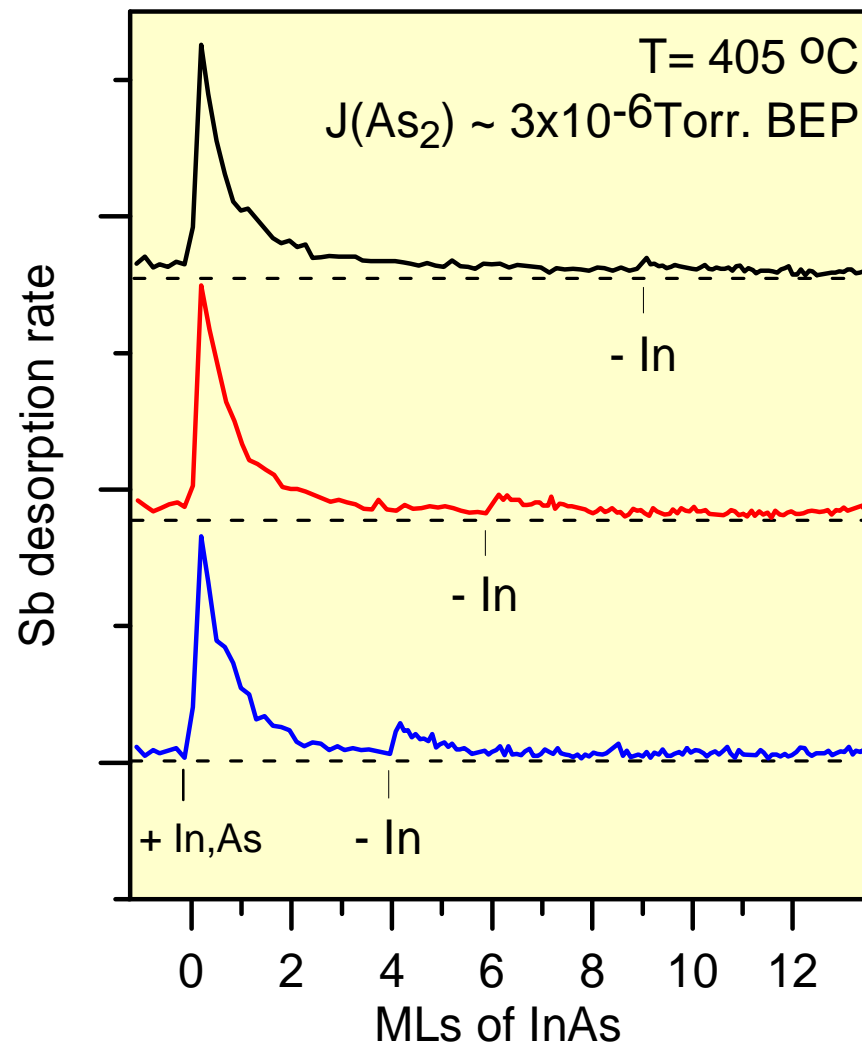
As-for-Sb exchange at the surface is followed by bulk exchange and almost all of the Sb in the 5 ML's is eventually purged by exposure to arsenic at normal growth temperatures.



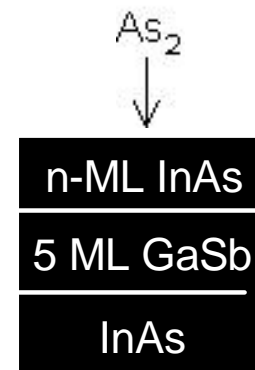
5 ML GaSb

InAs

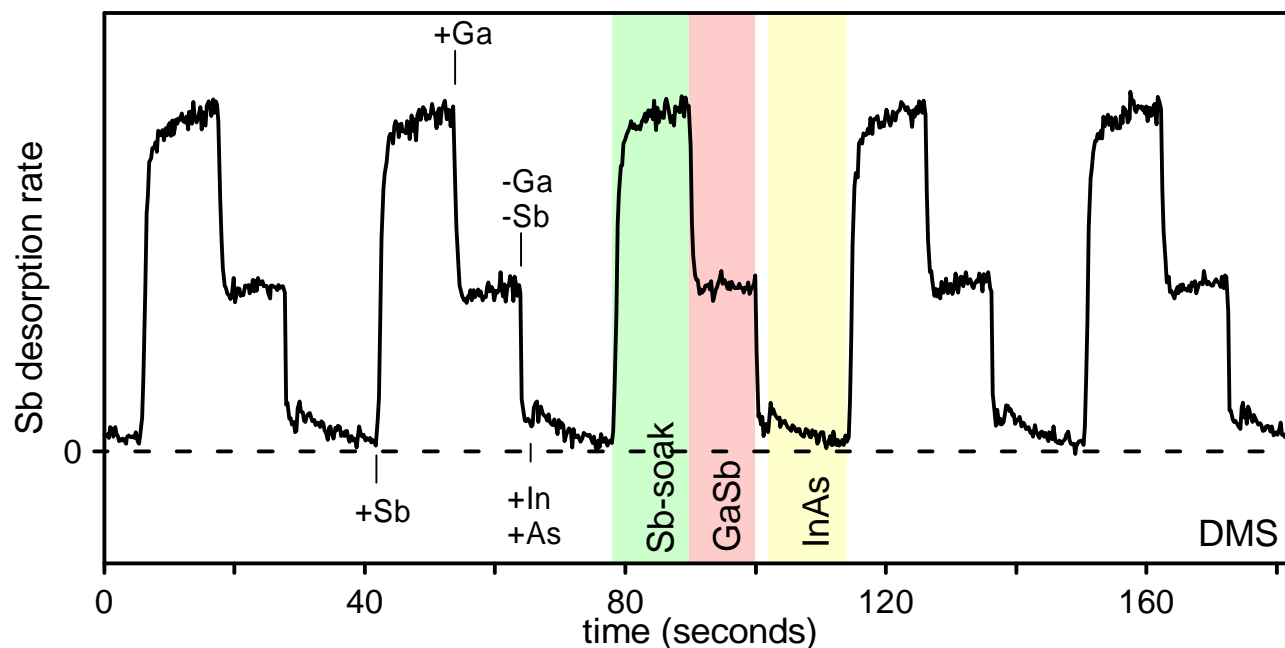
## Excess Sb rides the surface and incorporates into InAs



Sb desorption during InAs growth indicates Sb surface riding. Enhanced desorption after growth-interrupt indicates kinetic limitation to surface-riding, and incorporation of Sb into the InAs layer. Sb surface population diminishes as the growth surface moves further away from the InAs-on-GaSb interface.

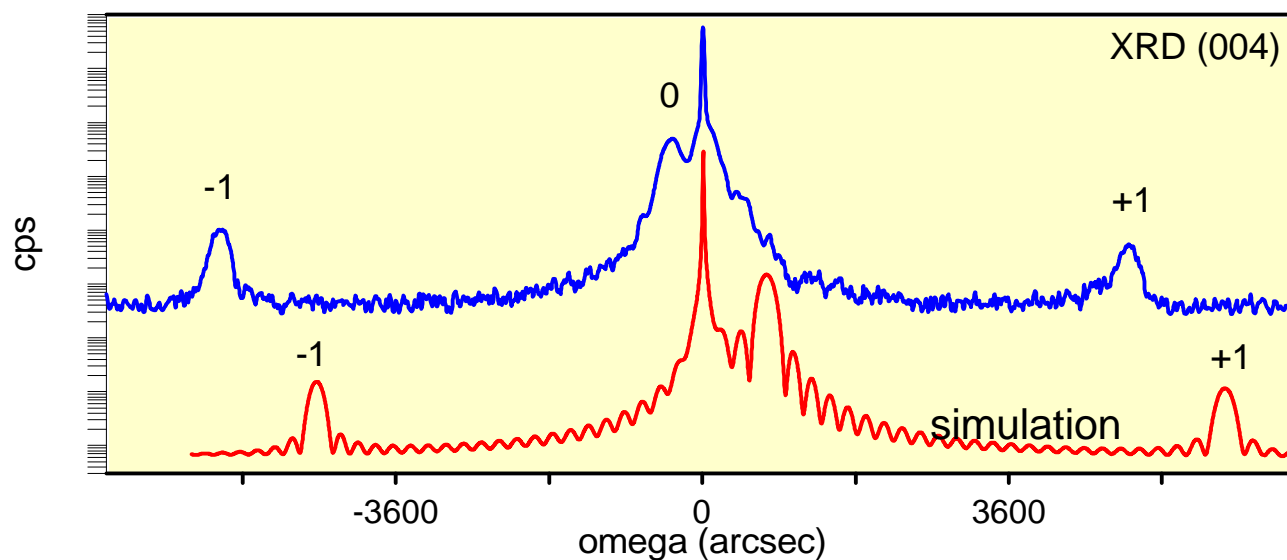


## InAs(6ML)/GaSb(6ML) SLS- no soak at InAs-on-GaSb interface

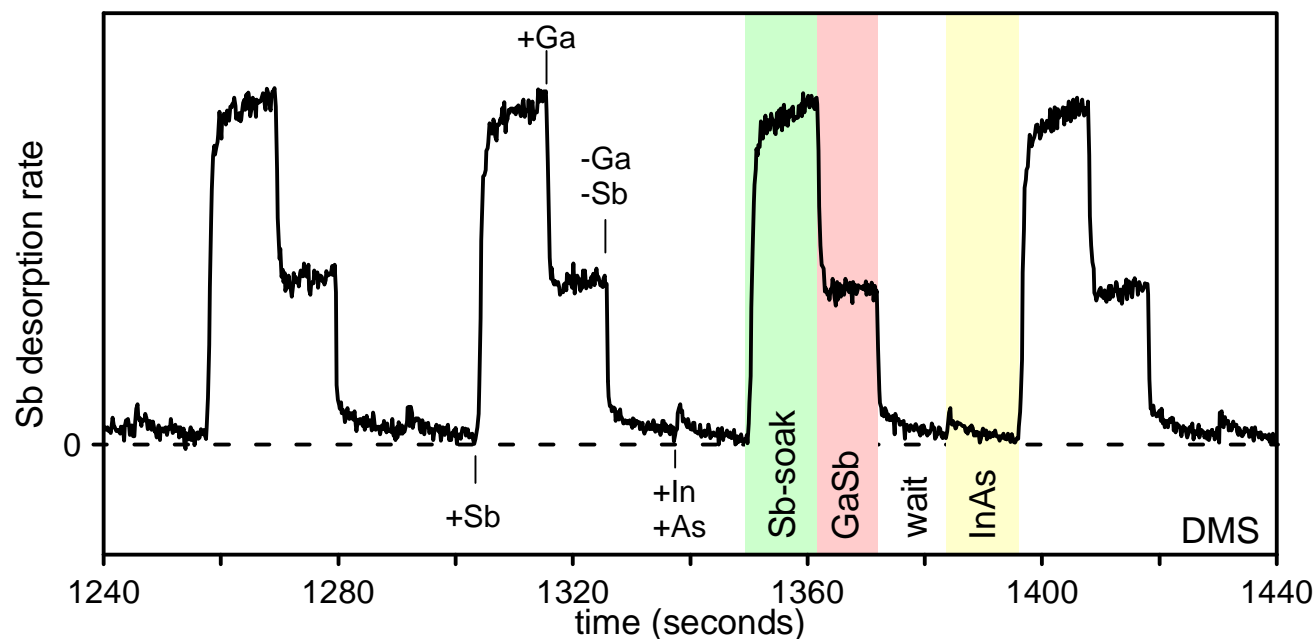


$T=400\text{ }^{\circ}\text{C}$   
 $J(\text{As}_2)=2\times 10^{-6}\text{ Torr.}$   
 $J(\text{Sb}_2)=1.5\times 10^{-6}\text{ Torr.}$   
 $R(\text{GaSb})=0.58\text{ ML/s}$   
 $R(\text{InAs})=0.5\text{ ML/s}$

Excess Sb at the GaSb surface incorporates into InAs and results in 0.15% average compressive strain in the SLS.

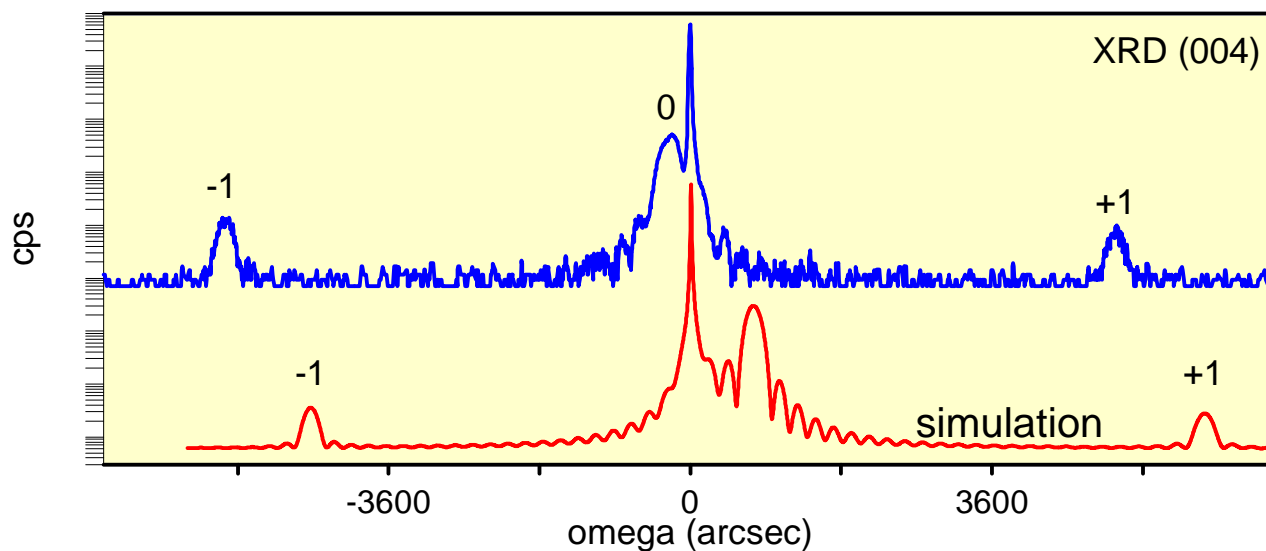


## InAs(6ML)/GaSb(6ML) SLS- 12s wait at the InAs-on-GaSb interface



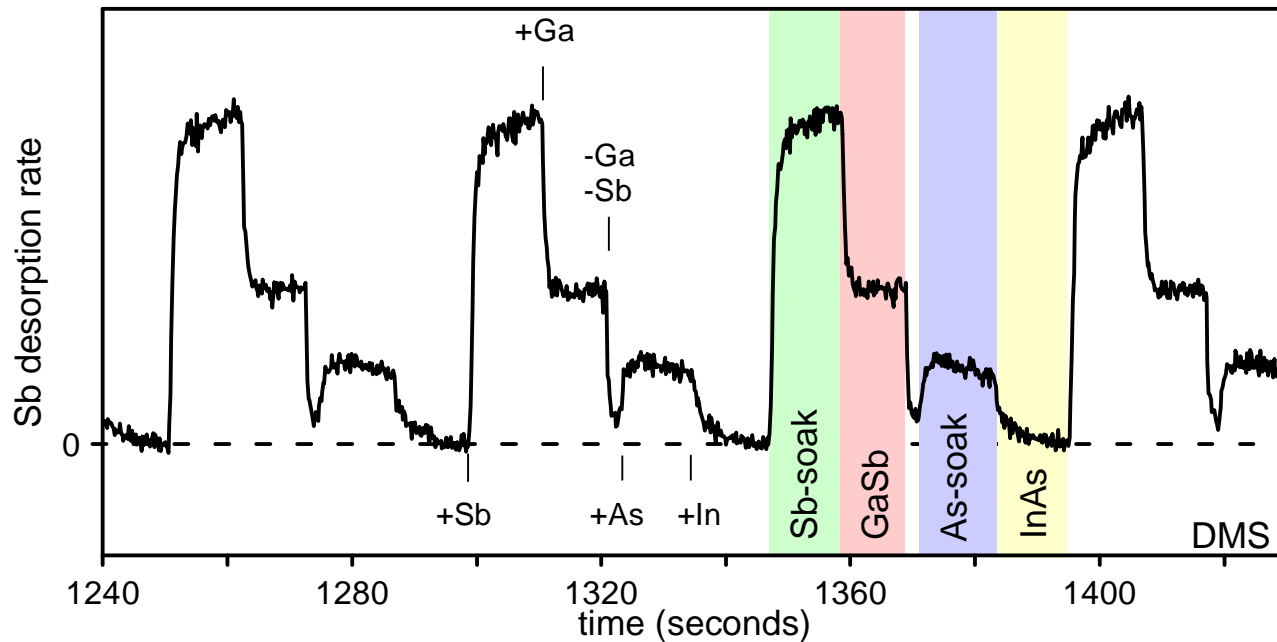
Sb in InAs still results in ~0.12 % compressive strain in SLS.

Waiting for the excess Sb population to leave the GaSb surface on its own has minimal effect. (i.e. need something to accelerate Sb removal).



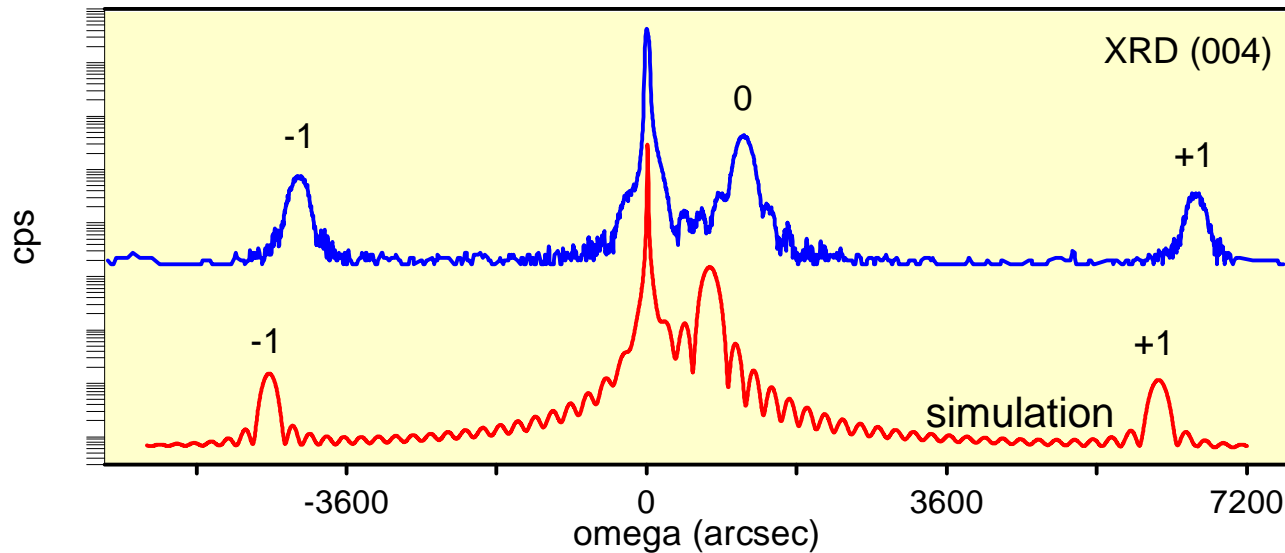


## InAs(6ML)/GaSb(6ML) SLS- 12s As-soak at the InAs-on-GaSb interface

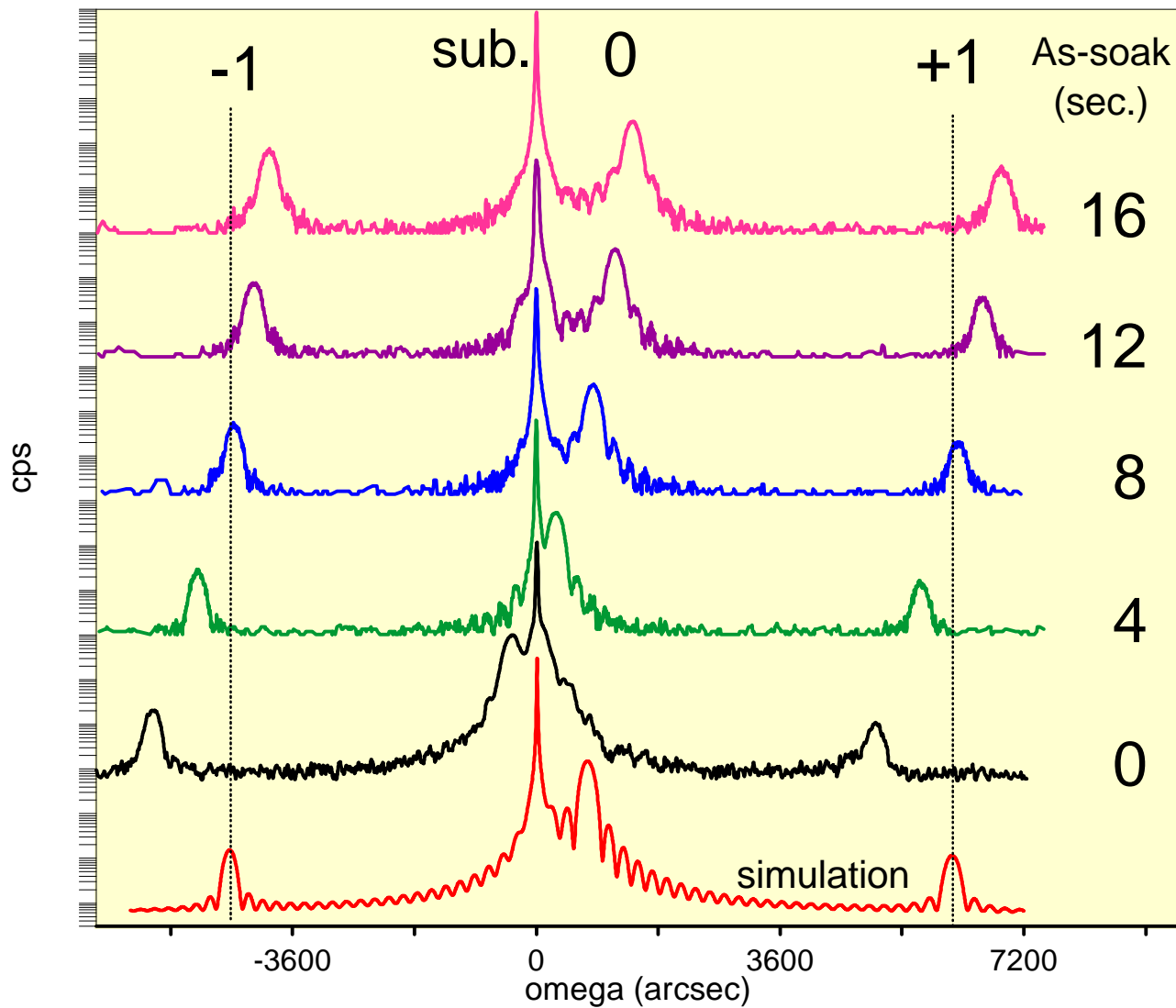


As can efficiently remove Sb but an excessive As-soak can remove more than the necessary amount of Sb.

12 sec. As-soak at these growth conditions has resulted in 0.45 % tensile strain in the SLS, 0.16% more than the ideal SLS.



## InAs(6)/GaSb(6) SLS- As-soak time varied



Given a set of MBE growth parameters, the As-soak time can be optimized to give the required SLS strain. Based on desorption measurements, this condition corresponds to improved compositional abruptness at the InAs-on-GaSb interface.

